GPIB-110
User Manual

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National Instruments Corporate Headquarters
6504 Bridge Point Parkway
Austin, TX 78730-5039
(512) 794-0100
Technical support fax: (800) 328-2203
(512) 794-5678

Branch Offices:
Australia (03) 879 9422, Austria (0662) 435986, Belgium 02/757.00.20, Canada (Ontario) (519) 622-9310,
Canada (Québec) (514) 694-8521, Denmark 45 76 26 00, Finland (90) 527 2321, France (1) 48 14 24 24,
Germany 089/741 31 30, Italy 02/48301892, Japan (03) 3788-1921, Netherlands 03480-33466, Norway 32-848400,
Spain (91) 640 0085, Sweden 08-730 49 70, Switzerland 056/20 51 51, U.K. 0635 523545

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A Return Material Authorization (RMA) number must be obtained from the factory and clearly marked on the outside of the package before any equipment will be accepted for warranty work. National Instruments will pay the shipping costs of returning to the owner parts which are covered by warranty.

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FCC/DOC Radio Frequency Interference Compliance

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual, may cause interference to radio and television reception. This equipment has been tested and found to comply with the following two regulatory agencies:

Federal Communications Commission

This device complies with Part 15 of the Federal Communications Commission (FCC) Rules for a Class A digital device. Operation is subject to the following two conditions:

1. This device may not cause harmful interference in commercial environments.

2. This device must accept any interference received, including interference that may cause undesired operation.

Canadian Department of Communications

This device complies with the limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communications (DOC).

Le présent appareil numérique n'émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de classe A prescrites dans le règlement sur le brouillage radioélectrique édicté par le ministère des communications du Canada.

Instructions to Users

These regulations are designed to provide reasonable protection against harmful interference from the equipment to radio reception in commercial areas. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

There is no guarantee that interference will not occur in a particular installation. However, the chances of interference are much less if the equipment is installed and used according to this instruction manual.

If the equipment does cause interference to radio or television reception, which can be determined by turning the equipment on and off, one or more of the following suggestions may reduce or eliminate the problem.

- Operate the equipment and the receiver on different branches of your AC electrical system.
- Move the equipment away from the receiver with which it is interfering.
- Reorient or relocate the receiver's antenna.
- Be sure that the equipment is plugged into a grounded outlet and that the grounding has not been defeated with a cheater plug.

Notice to user: Changes or modifications not expressly approved by National Instruments could void the user's authority to operate the equipment under the FCC Rules.

If necessary, consult National Instruments or an experienced radio/television technician for additional suggestions. The following booklet prepared by the FCC may also be helpful: *How to Identify and Resolve Radio-TV Interference Problems.* This booklet is available from the U.S. Government Printing Office, Washington, DC 20402, Stock Number 004-000-00345-4.

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About This Manual

The *GPIB-110 User Manual* describes how to install, configure, and operate the GPIB-110. The GPIB-110 is a high-performance bus extender that converts IEEE 488 signals into data packets for transmission to a matching GPIB-110, using a serial communication link to the distant extender. The receiving extender converts the packets back to IEEE 488 signals.

Organization of This Manual

This manual is organized as follows:

- Chapter 1, *Description of the GPIB-110*, contains general information about the National Instruments GPIB-110, lists the contents of the GPIB-110 kit, and explains how to unpack the GPIB-110 kit.
- Chapter 2, *Configuration and Installation*, contains instructions for configuring, installing, and verifying the operation of the GPIB-110.
- Chapter 3, *Theory of Operation*, contains an overview of the GPIB-110 and explains the operation of each part of the GPIB-110.
- Appendix A, *Hardware Specifications*, lists the specifications of the GPIB-110.
- Appendix B, *Multiline Interface Messages*, lists the multiline interface messages and describes the mnemonics and messages that correspond to the interface functions. These functions include initializing the bus, addressing and unaddressing devices, and setting device modes for local or remote programming. The multiline interface messages are IEEE 488-defined commands that are sent and received with ATN TRUE.
- Appendix C, *Operation of the GPIB*, describes some basic concepts you should understand to operate the GPIB. It also contains a description of the physical and electrical characteristics as well as configuration requirements of the GPIB.
- Appendix D, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products and manuals.
- The *Glossary* contains an alphabetical list and description of terms used in this manual, including abbreviations, acronyms, metric prefixes, mnemonics, and symbols.
- The *Index* contains an alphabetical list of key terms and topics in this manual, including the page where you can find each one.

Conventions Used in This Manual

The following conventions are used in this manual:

italic	Italic text denotes emphasis, a cross reference, or an introduction to a key concept.
bold italic	Bold italic text denotes a note, caution, or warning.
`monospace`	Text in this font denotes sections of code and names of functions.

Abbreviations, acronyms, metric prefixes, mnemonics, symbols, and terms are listed in the *Glossary*.

Related Documentation

The following manual contains information that may be helpful as you read this manual:

ANSI/IEEE Standard 488.1-1987, *IEEE Standard Digital Interface for Programmable Instrumentation*

Customer Communication

National Instruments wants to receive your comments on our products and manuals. We are interested in the applications you develop with our products, and we want to help if you have problems with them. To make it easy for you to contact us, this manual contains comment and configuration forms for you to complete. These forms are in Appendix D, *Customer Communication*, at the end of this manual.

Chapter 1
Description of the GPIB-110

This chapter contains general information about the National Instruments GPIB-110, lists the contents of the GPIB-110 kit, and explains how to unpack the GPIB-110 kit.

The GPIB-110 is a high-performance bus extender with the following features:

- Transparent to user software
- Extends the distance between GPIB instruments up to 2 km
- Transfer rates up to 144 kbytes/s
- Choice of fiber optic or coaxial cable
- Passes control over the GPIB
- FCC Class A (verified) noise emission
- Optional rack-mount hardware

The high-speed GPIB-110 Bus Extender, shown in Figure 1-1, is used in pairs with serial fiber optic or coaxial cables to connect two separate GPIB or IEEE 488 bus systems in a functionally transparent manner. While the two bus systems are physically separate, as shown in Figure 1-2, devices operate as if located on the same bus, as shown in Figure 1-3.

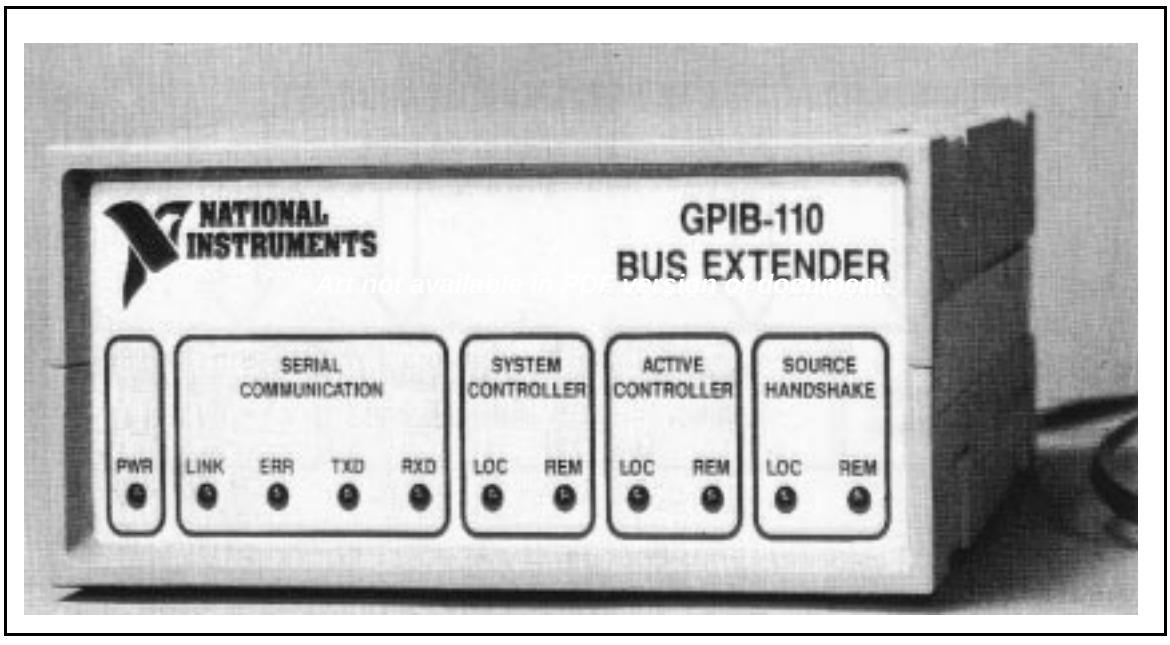


Figure 1-1. The Model GPIB-110 Bus Extender

At short distances, the data transfer rate over the extension can exceed 144 kbytes/s. The transfer rate degrades as the distance increases. There is no speed degradation for transfers between devices on the same side of the extension. Because the GPIB-110 is a functionally transparent extender, the same GPIB communications and control programs that operate with an unextended system work unmodified with an extended system. When conducting a parallel poll, with an extended system, minor modifications are necessary. These are explained in the section titled, *Parallel Poll Response (PPR) Modes,* in Chapter 2 of this manual.

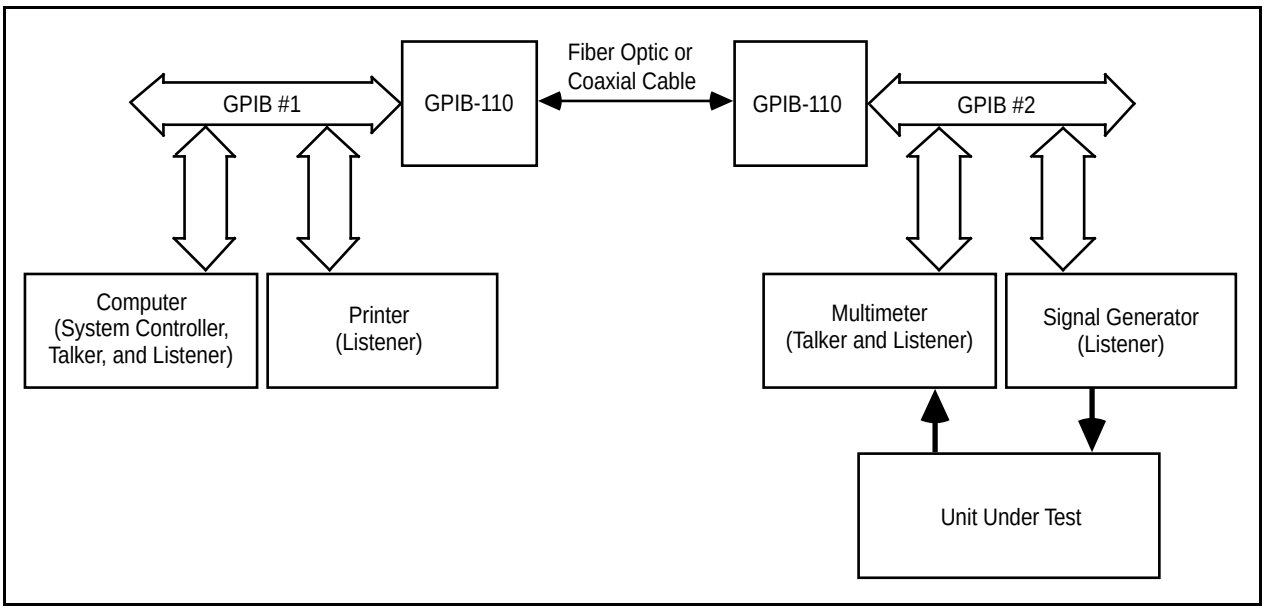


Figure 1-2. Typical GPIB-110 Extension System (Physical Configuration)

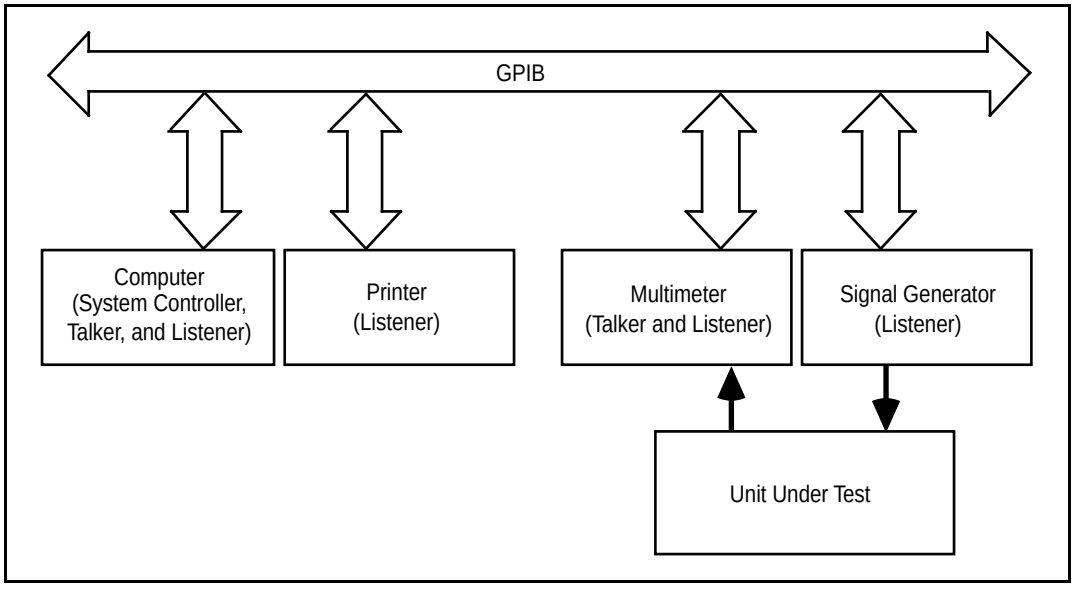


Figure 1-3. Typical GPIB-110 Extension System (Logical Configuration)

With the GPIB-110, you can overcome the two following configuration restrictions imposed by ANSI/IEEE Standard 488-1987:

- Cable length limit of 20 m per contiguous bus or 2 m times the number of devices on the bus, whichever is smaller.
- Electrical loading limit of 15 devices per contiguous bus.

Each GPIB-110 system extends the distance limit by 2 km and the loading limit to 30 devices including the extenders. You can connect these point-to-point extender systems in series for longer distances or in star patterns for additional loading.

What Your Kit Should Contain

Your GPIB-110 kit should contain the following components:

Kit Component	Part Number
Model GPIB-110 Bus Extender	
100-120 VAC:	
Fiber Optic Version	776103-01
Coaxial Version	776103-02
Dual Fiber Optic and Coaxial Capability	776103-03
220-240 VAC:	
Fiber Optic Version	776103-31
Coaxial Version	776103-32
Dual Fiber Optic & Coaxial Capability	776103-33
Power Cord:	
U.S. standard 3-wire power cable	763000-01
GPIB-110 User Manual	320052-01

Optional Equipment

You can call National Instruments to order the following optional equipment to go with your kit.

Equipment	Part Number
Rack-Mount Kit:	
Single Rack-Mount Kit	180304-01
Dual Rack-Mount Kit	180304-02
Transmission Cable*:	
Type T3 – Fiber Optic Cable	178058-xxx
Type T4 – Coaxial Cable	178057-xxx
	(xxx = length in meters)
Type X2 GPIB Cable:	
1 m	763061-01
2 m	763061-02
4 m	763061-03
8 m	763061-04
*For plenum cables, contact National Instruments.	

Unpacking

Follow these steps when unpacking your GPIB-110:

1. Verify that the pieces contained in the package you received match the kit parts list given earlier in this chapter.
2. Before you operate the GPIB-110, inspect the shipping container and its contents for damage. Keep the packaging material for possible inspection and/or reshipment.

   If the equipment appears to be damaged, do not attempt to operate it. Contact National Instruments for instructions. If the damage appears to have been caused in shipment, file a claim with the carrier.
3. The GPIB-110 is shipped from the factory with a 100 to 120 VAC or 220 to 240 VAC power supply. Verify that the voltage on the power supply matches the voltage that is supplied in your area.

   Caution: ***Operating the GPIB-110 at any voltage other than the one specified could damage the unit.***

Chapter 2
Configuration and Installation

This chapter contains instructions for configuring, installing, and verifying the operation of the GPIB-110.

Users unfamiliar with the GPIB should first read Appendix C, *Operation of the GPIB*, to become familiar with GPIB terminology and protocol before continuing with this chapter.

The GPIB-110 comes in the following three models:

- The 776103-01 (776103-31) model–Uses an optical fiber cable.
- The 776103-02 (776103-32) model–Uses a coaxial cable.
- The 776103-03 (776103-33) model–Uses either type of cable.

The GPIB-110 has several configurations depending on the type and length of cable used and other operating conditions.

Grounding Configuration

A U.S. standard 3-wire power cable is provided with the GPIB-110. When connected to a power source, this cable connects the equipment chassis to the power ground.

The GPIB-110 is shipped from the factory with the logic ground of the digital circuitry connected to both the power and chassis ground and interfacing cable shields.

If it is necessary to isolate either of these grounds to prevent current loops between units, disassemble the unit according to the following instructions.

Warning: ***Hazardous voltage inside. Remove power cord before opening unit.***

1. Turn the power switch to OFF. This switch is located on the rear panel of the GPIB-110.
2. Disconnect the power cord from the power source and from the rear panel of the GPIB-110.
3. Remove the cover from the GPIB-110 by first removing the two screws located on each side of the housing. Lift off the cover.

   To isolate the interface cable shield from the chassis, power ground, and logic ground, change the interface cable Shield Selection Jumper shown in Figure 2-1, letter c, to the position labeled ISO.

To isolate the digital logic ground from the chassis and power ground, change the chassis ground to Logic Ground Selection jumpers shown in Figure 2-1, letter a, to the position labeled ISO.

4. Replace the cover. Be sure the aluminum side plates are in the proper place.
5. Replace the screws you removed in Step 3.

6. Reconnect the power cord.

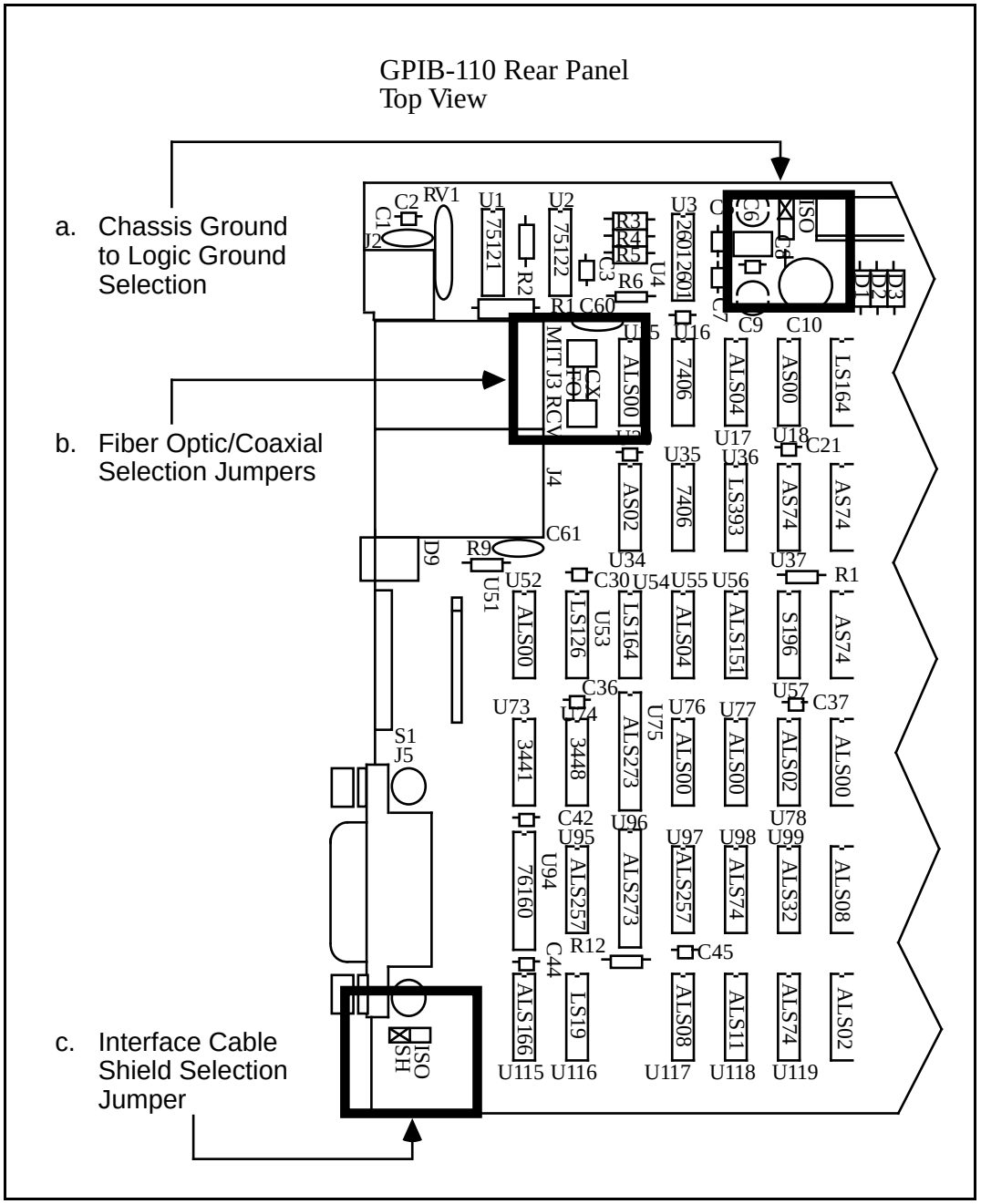


Figure 2-1. Isolation Selection

The GPIB-110 Front and Rear Panels

In the following discussions, the terms *local* and *remote* refer to certain states of the two GPIB-110 Bus Extenders. When one extender is in a local state, meaning that the state in question originated on its side, the other extender is in the corresponding remote state. The three states in question are the System Controller, Active Controller, and Source Handshake.

The GPIB-110 Front Panel

The GPIB-110 front panel is shown in Chapter 1, Figure 1-1. The front panel has nine Light Emitting Diodes (LEDs). The PWR LED on the left side of the front panel lights up whenever power is applied to the GPIB-110.

The Serial Communication LEDs are LINK and ERR (error). The GPIB-110 condenses the 16 IEEE 488 signals into data packets that are sent across the serial link and are converted back to IEEE 488 signals by the remote GPIB-110. When lit, the LINK LED indicates that the remote GPIB-110 is on and the extension is operating normally. The ERR LED flashes whenever a data packet containing an error is received.

The System Controller, Active Controller, and Source Handshake each have two LEDs indicating local (LOC) and remote (REM). If the System Controller LOC LED is lit, the Interface Clear (IFC) or Remote Enable (REN) message has been detected on the local GPIB. If the System Controller REM LED is lit, IFC or REN has been received from the remote unit. If the Active Controller LOC LED is lit, the Attention (ATN) message has been detected on the local GPIB. If the Active Controller REM LED is lit, ATN has been received from the remote unit. If the Source Handshake LOC LED is lit, a Data Valid (DAV) message has been detected on the local GPIB; that is, the Talker is on the local GPIB. If the REM LED lights up, DAV has been received from the remote unit; that is, the Talker is on the remote side.

The GPIB-110 Rear Panel

The GPIB-110 rear panel is shown in Figure 2-2. The rear panel contains all the GPIB-110 connectors and switches.

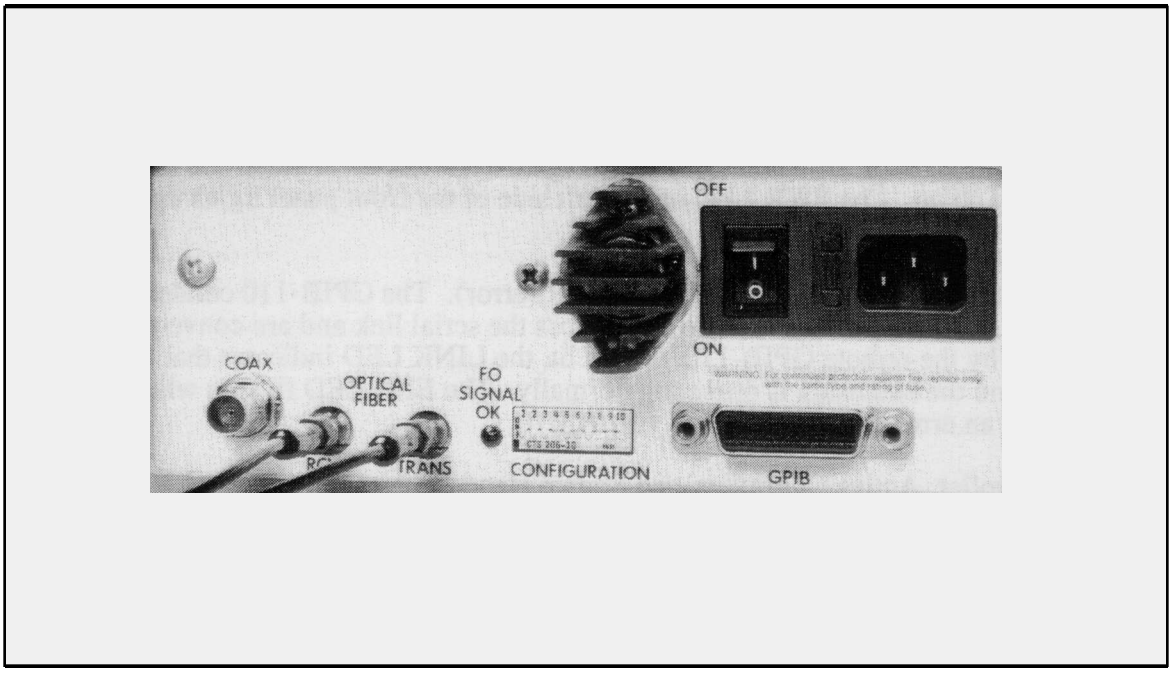


Figure 2-2. Rear Panel

The rear panel shown is for the 776103-03 (776103-33) model, which supports both fiber optic and coaxial cable.

For all models, the power switch is located on the upper right corner of the rear panel. The fuse housing is located directly to the right of the power switch. The GPIB connector is located directly below the power switch and is labeled GPIB. To the left of the GPIB connector (center bottom of panel) is the configuration switch, which is labeled CONFIGURATION.

For the 776103-01 (776103-31) and 776103-03 (776103-33) models, an LED is located to the left of the configuration switch. The LED labeled FO SIGNAL OK is lit when the signal quality received over the fiber optic cable is good. To the left of the LED are the optical fiber connectors labeled RCVR for receive and TRANS for transmitter.

For the 776103-02 and 776103-03 models, the coaxial cable connector is located on the left-most bottom corner of the rear panel. The connector is labeled COAX.

GPIB-110 Setup

Configure the GPIB-110 units before installing them and running the cable between them. This step makes configuration easier. The main configuration switch is used to select other operating modes. This switch is located on the rear panel of the GPIB-110 and, in most cases, is the only switch you need to set before installing the GPIB-110s. Be sure to power-off the GPIB-110 before changing any switches. Figure 2-3 shows the default settings of the configuration switch.

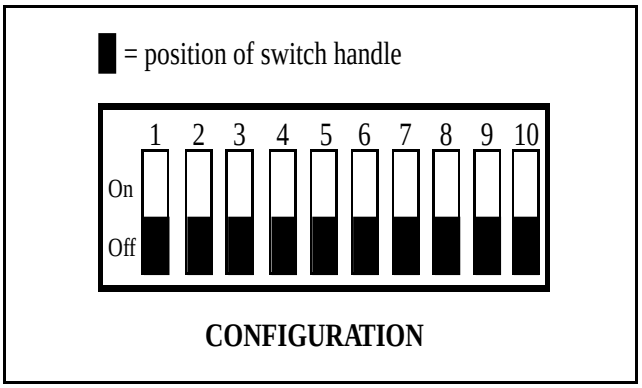
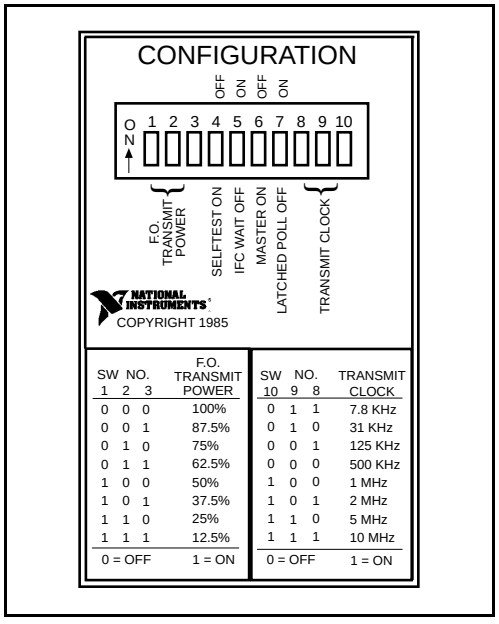


Figure 2-3. Configuration Switch

The GPIB-110 has a label on the bottom of the box with important information. This label shows the ten configuration switches with their names. The bottom left corner of the label lists the Fiber Optic Transmit power settings. For more information on setting these switches, refer to the section titled *Fiber Optic Transmit Power*, later in this chapter. The bottom right corner of the label lists the configuration switch settings for Switches 8 through 10 and the corresponding Transmit Clock Values. For more information, refer to the section titles *Transmit Clock*, later in this chapter. Figure 2-4 shows the label on the bottom of the GPIB-110.



SW NO. 1 2 3	F.O. TRANSMIT POWER
0 0 0	100%
0 0 1	87.5%
0 1 0	75%
0 1 1	62.5%
1 0 0	50%
1 0 1	37.5%
1 1 0	25%
1 1 1	12.5%
0 = OFF	1 = ON

SW NO. 10 9 8	TRANSMIT CLOCK
0 1 1	7.8 KHz
0 1 0	31 KHz
0 0 1	125 KHz
0 0 0	500 KHz
1 0 0	1 MHz
1 0 1	2 MHz
1 1 0	5 MHz
1 1 1	10 MHz
0 = OFF	1 = ON

Figure 2-4. GPIB-110 Label

Place the GPIB-110s in close proximity and connect the cable to be used to each unit.

Cable Selection

The GPIB-110 is shipped with either a coaxial or fiber optic cable and with the cable selection jumper set according to the model number. However, if you have to change the type of cable you are using, you must also change the jumper setting located on the inside of the GPIB-110 as shown in Figure 2-5. (See Figure 2-1, letter b, for the location of this jumper.)

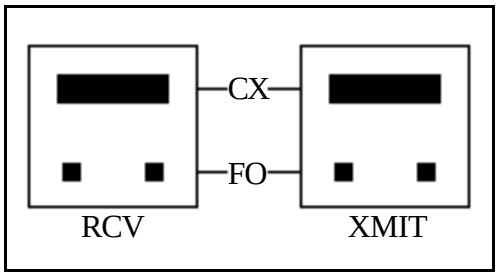


Figure 2-5. Internal Cable Selection Jumper (Shown for Coaxial Cable)

Use the following steps to change the setting of the cable selection jumper.

Warning: ***Hazardous voltage inside. Remove power cord before opening unit.***

1. Turn the power switch to OFF. This switch is located on the rear panel of the GPIB-110.
2. Disconnect the power cord from the power source and from the rear panel of the GPIB-110.
3. Remove the cover from the GPIB-110 by first removing the two screws located on each side of the housing. Lift off the cover.
4. The Internal Cable Selection Jumper, shown in Figure 2-5, is located underneath the transformer near the rear panel. (See Figure 2-1, letter b, for the exact location.) Using needle-nosed pliers (right angle works best), place the two blue jumpers on the correct setting. The position labeled FO is for fiber optic cable. The position labeled CX is for coaxial cable.
5. Replace the cover. Be sure the aluminum side plates are in the proper place.
6. Replace the screws you removed in Step 3.
7. Reconnect the power cord.

Coaxial Cable Setup

The coaxial cable should be connected to the Coaxial BNC connector on the rear panel of the GPIB-110. When using a coaxial cable, Switch 4 on the rear panel configuration switch must be set to ON (Self-Test mode OFF), and Switches 5 through 10 must be configured as explained in the following sections. Refer to Figure 2-3 for the default settings of the configuration switch and Figure 2-4 for other possible configurations.

Fiber Optic Cable Setup

The fiber optic cable comes with two SMA-style connectors on each end. One connector should be marked T for transmit; the other should be marked R for receive. Connect the connector marked T to the fiber optic connector marked TRANS on the GPIB-110 rear panel. Connect the connector marked R to the fiber optic connector marked RCVR on the GPIB-110 rear panel. The connectors are connected by pushing the cable connector gently into the rear panel connector and screwing the cable connector onto the rear panel connector securely.

When a fiber optic cable is used, Switch 4 on the rear panel configuration switch must be set to the ON (Self-Test mode OFF) position, and Switches 1 through 3 and 5 through 10 must be configured as explained in the following sections. Refer to Figure 2-3 for the default settings and to Figure 2-4 for configuration options for fiber optic cable setup.

Master Switch Setting

The operation of the GPIB-110 requires one of the connected pairs of GPIB-110s to be configured as the master. The master GPIB-110 is the one that initiates communication between the GPIB-110s. Either side can be the master. On one of the GPIB-110s, set Switch 6 to the ON position. Set Switch 6 of the other GPIB-110 to the OFF position. The GPIB-110 with the master switch set in the OFF position is master.

Note: ***The master switch settings are reversed from the markings that appear on the switch. To set your GPIB-110 as master, you must set the switch in the OFF position.***

Fiber Optic Transmit Power

The Fiber Optic Transmit Power settings apply only to the GPIB-110 models using fiber optic cable.

The Fiber Optic Transmit Power is adjustable from 12.5 percent to 100 percent power. Operating the fiber optic transmitter at a lower power decreases power dissipation in the GPIB-110 and can extend the life of the optical transmitter. The transmit power setting depends on the length of optical fiber cable used.

Switches 1, 2, and 3 are used to set the transmit power of the transmitter LED. Figure 2-3 shows the default settings for each switch and Figure 2-4 shows the power settings for the configuration switch settings.

You must determine which power setting to use when the GPIB-110s are connected with the fiber optic cable. The following steps list how to determine the power setting:

1. Turn on both GPIB-110s.
2. Set the transmit power switches on one of the GPIB-110s to the lowest power setting (Switches 1, 2, and 3 in the ON position) and observe the SIGNAL OK LED on the rear panel of the other GPIB-110 unit.
3. Increase the transmit power by changing the switches until the SIGNAL OK LED lights up on the other GPIB-110. Then increase the power setting by one.
4. Set the transmit power switches on the other GPIB-110 to the same configuration.

Transmit Clock

The GPIB-110 has a variable transmit frequency that must be set for a given length of fiber optic or coaxial cable. If you are using fiber optic cable, set the transmit clock to 10 MHz for any length of cable. For a coaxial cable, you must reduce the transmit clock values as the cable length increases. Set Switches 8, 9, and 10 on the rear panel configuration switch so the transmit clock value corresponds to your cable length. Table 2-1 shows the appropriate transmit clock values versus cable length.

Table 2-1. Transmit Clock Values Versus Cable Length

Cable Type	Cable Length	Transmit Clock	Configuration Switch Setting		
			10	9	8
Coaxial Cable	0 m to 240 m	10 MHz	1	1	1
	240 m to 425 m	5 MHz	1	1	0
	425 m to 730 m	2 MHz	1	0	1
	730 m to 1035 m	1 MHz	1	0	0
	1035 m to 1340 m	500 KHz	0	0	0
	1340 m to 1765 m	125 KHz	0	0	1
	1765 m to 2000 m	31 KHz	0	1	0
			Note: 0 = Off 1 = ON		
Fiber Optic Cable	Any Length	10 MHz	1	1	1

Extension Modes

The GPIB-110 has two extension modes–Immediate Extension mode and IFC Wait mode. Both GPIB-110 units in the extension system must be set to the same mode using Switch 5, which is located on the rear panel configuration switch.

Immediate Extension Mode

The GPIB-110 is set at the factory to the Immediate Extension mode (Switch 5 OFF). In this mode, the extenders connect the two local GPIB buses as soon as they are both turned on.

IFC Wait Mode

In IFC Wait Mode (Switch 5 ON), the GPIB-110s do not connect the two local GPIB buses until an IFC signal is detected. This mode requires a System Controller on one side of the extension and any number of Talkers, Listeners, and other Controllers in the system. This mode causes the GPIB-110s to be synchronized with the local buses so that the buses do not disturb each other when the GPIB-110s are turned on.

In IFC Wait mode, the two GPIB-110s wait to detect the following information in this sequence:

1. The Interface Clear (IFC) signal from the System Controller
2. The Attention (ATN) signal from the Active Controller
3. The Data Valid (DAV) signal from the Active Controller or Talker

Both units turn on in a quiescent condition without an active local or remote state. They remain this way until one unit detects an IFC true from the System Controller that is on the same contiguous bus. That unit enters the Local System Controller (LSC) state and causes the other unit to enter the Remote System Controller (RSC) state. The IFC and Remote Enable (REN) signals are switched to flow from the local to the remote unit. Next, one unit detects the Attention (ATN) signal from the Active Controller, enters the Local Active Controller (LAC) state, and places the other unit in the Remote Active Controller (RAC) state. The ATN signal is switched to flow from the local to the remote side and the Service Request (SRQ) is switched to flow in the opposite direction. Finally, one unit detects the Data Valid (DAV) signal from the Source Handshake function of the Talker or Active Controller. That unit enters the Local Source (LS) state and places the other unit in the Remote Source (RS) state. The DAV and Data (DIO) signals are switched to flow from local to remote side, and the Not Ready for Data (NRFD) and Not Data Accepted (NDAC) signals are switched to flow from remote to local side.

As the source side for these three key signals (IFC, ATN, and DAV) change, the local/remote states of each extender change. The directions of the other GPIB signals change accordingly. See the *Active Controller Detection* and *Source Handshake Detection* sections in Chapter 3 for more information about this operation.

Parallel Poll Response (PPR) Modes

According to the ANSI/IEEE Standard 488-1987, devices must respond to a parallel poll within 200 ns after the Identify (IDY) message is asserted by the Active Controller, which then waits 2 µs or more to read the Parallel Poll Response (PPR). A remote device on an extended system cannot respond this quickly because of cable propagation delay. GPIB extender manufacturers have approached this problem in three ways:

Approach 1: Respond to IDY within 200 ns with the results of the previous poll of the remote bus.

Approach 2: Ignore the 200 ns rule and assume the Controller will wait sufficiently long to capture the response.

Approach 3: Do not support parallel polling at all.

The GPIB-110 supports either Approach 1 or 2 selected by Switch 7, which is located on the rear panel configuration switch as shown in Figure 2-3.

Latched PPR Mode (Approach 1)

This mode is selected by setting Switch 7 ON. Most Controllers pulse the IDY signal for a period of time exceeding 2 µs and expect a response within that time. When used with this type of Controller, the GPIB-110 must be set in the Latched PPR mode. After power on, the initial poll response is FFH, subsequent poll responses are the results of the previous poll.

In this mode, the local GPIB-110 extender responds to IDY by outputting the contents of the PPR data register. At the same time, a parallel poll message is sent to the remote bus and the poll response is returned to the local unit. When the local IDY signal is unasserted, the register is loaded with the new remote response. Consequently, the register contains the response of the previous poll. To obtain the response of both the local and remote buses, the control program executes two parallel polls back-to-back and uses the second response.

The software driver library of most Controllers contains an easy-to-use parallel poll function. For example, if the function is called `PPOLL` and the control program is written in BASIC, the sequence to conduct a poll in Latched PPR mode might be like this:

```
CALL PPOLL(PPR)
CALL PPOLL(PPR)
IF PPR  >  0 GOTO NNN
```

If two GPIB extender systems are connected in series, three polls are necessary to get responses from the local, middle, and far buses.

Unlatched PPR Mode (Approach 2)

Many Hewlett-Packard GPIB Controllers remain in a parallel poll state with IDY asserted whenever they are not performing another function. A change in the response causes an interrupt of the control program. In other Controllers, the IDY signal is toggled on and off and the duration of the signal can vary to accommodate delayed responses over extenders.

When used with these types of Controllers, the GPIB-110 should be set to Unlatched PPR mode by setting Switch 7 to the OFF position. This means that the IDY message is sent to the remote bus and the response is returned as fast as propagation delays allow. It is the responsibility of the Controller to wait long enough for the response.

Mixed Mode Option

If there are multiple Controllers and all of the same type are located on the same side of the extension, the two GPIB-110 units can be set to Latched and Unlatched PPR modes accordingly.

Installation

After configuring both GPIB-110s and connecting the coaxial or fiber optic cable, follow these instructions:

Verify the Voltage Requirement

The GPIB-110 is shipped from the factory with either a 100 to 120 VAC or 220 to 240 VAC internal power supply. Verify that the voltage specified on the power supply matches the voltage supplied in your area.

Caution: ***Operating the unit at any voltage other than the one specified could damage the unit.***

1. Plug the utility power cord into an acceptable electrical outlet (100 to 120 VAC or 220 to 240 VAC, depending upon which model of the GPIB-110 you have). Then plug the other end of the power cord into the back panel of the GPIB.
2. Link the first GPIB to the GPIB-110 with an appropriate cable (Type X1 or better). The cable coming from the GPIB should be plugged into the back panel of the GPIB-110.
3. Link the second GPIB to the remote GPIB-110 with the appropriate GPIB cable.

Mounting

The GPIB-110 enclosure is designed for table top or rack-mount operation. Single- and dual-unit rack-mount kits are available from National Instruments.

Power On

The GPIB-110 extension system is fully operational when power is applied to both units and they are connected. If the extenders are set for IFC Wait Mode, it may be necessary to turn on the System Controller last after the extenders and all other devices are operating. This step is necessary if the System Controller executes only one IFC shortly after power on.

The preferred operating mode is to keep both extenders and at least two-thirds of the devices on both buses turned on when there is any GPIB activity.

Self-Test Mode

The GPIB-110s are equipped with a Self-Test mode that determines if the GPIB-110 receivers, transmitters, and packet transmission and reception circuitry are operating correctly. This mode is controlled by Switch 4.

This mode should be used only if you want to check the operation of the GPIB-110. It is not necessary to use this mode to operate the GPIB-110s.

Note: ***The self-test switch settings are reversed from the markings that appear on the switch. To set your GPIB-110 for self-test mode, you must set the switch in the OFF position.***

Self-Test with Coaxial Cable

Use the following steps to run the Self-Test mode with the coaxial cable.

1. Turn the GPIB-110 power switch to OFF.
2. Disconnect the coaxial cable from the rear panel connector.
3. Set the master switch to the ON position (Switch 6 OFF) and the self-test switch to the ON position (Switch 4 OFF).
4. Turn the GPIB-110 power switch to ON.

At this point, the LINK LED on the front panel lights up indicating that the Self-Test mode is operating correctly. In addition, the ERR LED remains off.

Note: ***Be sure to turn the self-test switch to the OFF position (Switch 4 ON) and the master switch to the original position and reconnect the coaxial cable before re-using the GPIB-110.***

Self-Test with Fiber Optic Cable

To run the Self-Test mode with the fiber optic cable, you must connect a single fiber optic cable in a loop from the transmit output to the receive input of the GPIB-110. You can use the opposite ends of the extension cable, or purchase a short loopback cable from National Instruments.

Use the following steps to run the Self-Test mode with the fiber optic cable.

1. Turn the GPIB-110 power switch to OFF.
2. Disconnect the fiber optic cable from the rear panel transmit and receiver connectors.
3. Connect the transmitter connector to the receiver connector with a single fiber optic cable.
4. Set the master switch to the ON position (Switch 6 OFF) and the self-test switch to the ON position (Switch 4 OFF).
5. Turn the GPIB-110 power switch to ON.

At this point, the LINK LED on the front panel lights up indicating that the Self-Test mode is operating correctly. The ERR LED should remain off.

Note: ***Be sure to turn the self-test switch to the OFF position (Switch 4 ON) and the master switch to the original position and reconnect the fiber optic extension cable before re-using the GPIB-110.***

Connecting to Hewlett-Packard (HP) Controllers

To achieve high data transfer rates and long cable spans between devices, many HP controllers and computers, such as the 64000 series, use a *preload* technique on the unit designated Master Controller. When preloaded, the GPIB lines of the Master Controller are terminated to represent six device loads. HP has two types of preloading: Class A, in which all 16 GPIB lines are loaded, and Class B, in which all except Not Ready For Data (NRFD) and Not Data Accepted (NDAC) messages are loaded.

Preloading increases *ringing* on signal transitions and can cause improper operation of the GPIB-110. If this happens, set all signals on the Master Controller to normal (1-unit) load. This is done by using a back-panel switch. It is also important to limit the cabling to no more than 2m per device.

Chapter 3
Theory of Operation

This chapter contains an overview of the GPIB-110 and explains the operation of each part of the GPIB-110.

The GPIB-110 design consists of two main parts:

- The extension circuitry
- The serial communication circuitry

The *extension circuitry* monitors the local GPIB states and converts the signals monitored into the X (for transmit) signals that are sent to the serial communication circuitry.

The *serial communication circuitry* samples the X signal lines and serializes the information into packets that are transmitted to the remote GPIB-110 unit.

The serial communication circuitry decodes packets received from the remote unit and converts the packets into the parallel GPIB signals prefixed with an R (for receive) that are sent to the extension circuitry.

The extension circuitry monitors the R signal lines and drives the local GPIB lines accordingly.

Figure 3-1 shows a block diagram of the GPIB-110.

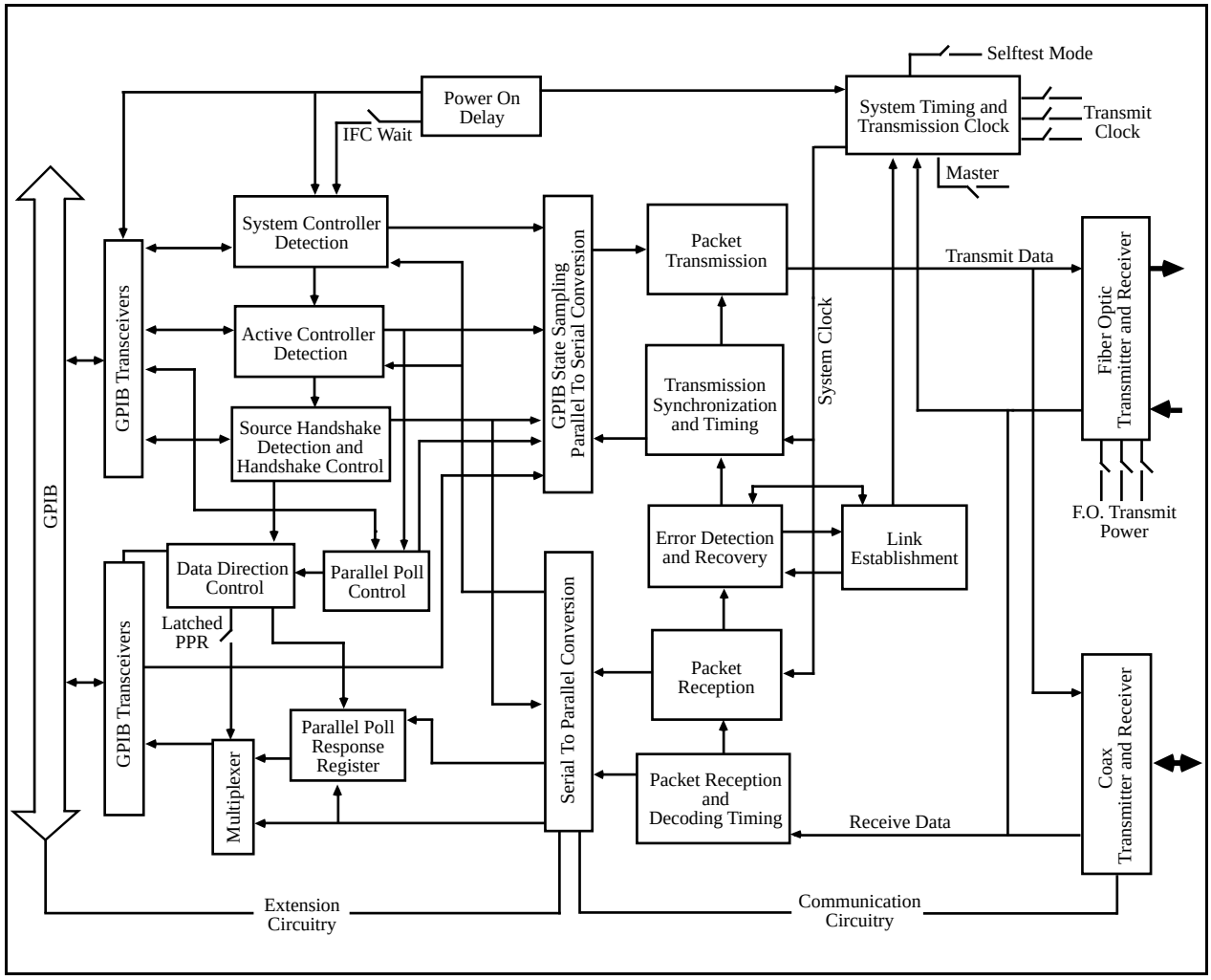


Figure 3-1. GPIB-110 Block Diagram

Extension Circuitry

The extension circuitry converts signals received from the local GPIB to the X signals, as shown in Figure 3-1, and drives the R signals onto the local GPIB. The X signals sent from one GPIB-110 unit after serialization and transmission, become the R signals on the remote GPIB-110 unit after being received and converted back into parallel form. The System Controller, Active Controller, and Source Handshake states on the GPIB-110 unit determine which GPIB signals are sensed and/or driven.

Power On

When the GPIB-110 is turned on, a reset pulse clears all circuitry to an initialized state. The units then begin executing the link establishment protocol, which is discussed in the *Link Establishment Protocol* section later in this chapter.

After the GPIB-110 is turned on, the GPIB transceivers are in a passive, receive state (not driving anything on the GPIB). The extender remains in this state until communication is established with the remote GPIB-110 unit.

Once the link is established, the GPIB-110 is able to monitor the local GPIB state and receive packets containing the remote GPIB state.

System Controller Detection

The GPIB-110 monitors the location of the System Controller with the System Controller detection circuitry.

When IFC or REN true is received from the local GPIB, the Local System Controller (LSC) state becomes true. The X.IFC or X.REN signal is then sent true to the communication circuitry where it is sent to the remote unit. The LSC state is cleared if R.IFC or R.REN is received true from the remote unit and IFC or REN is not true on the local GPIB.

R.IFC or R.REN true is received from the remote GPIB-110 unit, the Remote System Controller (RSC) state becomes true. The IFC and REN signals are then driven onto the local GPIB. The RSC state is cleared if IFC or REN true is sensed from the local bus and R.IFC or R.REN is not received true.

Active Controller Detection

The GPIB-110 monitors the location of the Active Controller with the Active Controller detection circuitry. The location of the Active controller is determined by sensing the location of ATN. After power on, the Remote Active Controller (RAC) and Local Active Controller (LAC) states are cleared.

When ATN is received from the local bus, the LAC state becomes true on the leading edge of ATN. X.ATN is then sent to the remote unit. LAC true allows the local unit to receive SRQ from the remote unit and to drive the SRQ line on the local bus. LAC is cleared if R.ATN is received from the remote unit and ATN is false on the local GPIB.

When R.ATN is received from the remote unit, the RAC state becomes true. When RAC is true, the local ATN signal is driven according to the state of R.ATN received from the remote side. The local state of SRQ is sent to the remote side (that is, to the Active Controller). RAC is cleared if ATN is true on the local GPIB and R.ATN is received false.

If IFC Wait mode is selected, both the RAC and LAC states remain cleared until either the LSC or the RSC state is true.

Source Handshake Detection

The GPIB-110 monitors the location of the Source Handshake. The location of the Source Handshake is determined by the location of DAV.

The Local Source (LS) Handshake and Remote Source (RS) Handshake states are cleared upon power on.

The LS Handshake state is also cleared on the following events:

- When IFC Wait mode is selected with Switch 5 on the rear panel configuration switch and before the Active Controller is identified
- Whenever ATN from the local bus or R.ATN changes state
- When ATN or DAV is received from the remote unit
- During a parallel poll

The Remote Source (RS) Handshake state is cleared during the following events:

- When IFC Wait Mode is selected with Switch 5 on the rear panel configuration switch and before the Active Controller is identified
- Whenever there is a change in state from the remote ATN signal
- When ATN or DAV is received from the local GPIB
- During a parallel poll

Until the LS state is true and unless a parallel poll is in progress, the unit drives the local NRFD signal passively false. After the Active Controller is identified (if in IFC Wait mode) and until the Source Handshake is identified, the unit drives NDAC true. Thus, the unit appears to the local GPIB to be in a normal RFD/NDAC state, awaiting the first data or command byte.

When DAV is received from the Local GPIB, the LS state becomes true. DAV is then sent to the remote unit as X.DAV.

When R.DAV is received from the remote unit, the signal is delayed 2 µs and the RS state becomes true. Once the RS state is true, DAV is driven onto the local GPIB. Subsequently, whenever R.DAV true is received from the remote unit, the signal is delayed 500 ns before being driven onto the local GPIB to satisfy T1. The local NRFD and NDAC are sensed and sent to the remote unit as X.RFD and X.DAC.

Once the LS state is true, the propagation of R.RFD from the remote side allows the handshake to continue. At this point, the unit drives the NRFD and NDAC lines according to the levels sensed at the remote unit and received as R.RFD and R.DAC.

Parallel Polling

When the GPIB-110 detects ATN and EOI simultaneously asserted on the local bus, the Parallel Poll-In-Progress state becomes true and X.EOI is transmitted to the remote side along with X.ATN. X.EOI and X.ATN continue to be propagated to the remote side until a Parallel Poll Response is returned from the remote unit, even if the local ATN and EOI signals become false. NRFD is asserted on the local bus during the Parallel Poll.

If the latched Parallel Poll Response (PPR) mode is selected, the contents of the PPR register are driven onto the local GPIB DIO lines. Otherwise, the local GPIB DIO lines are driven passively false until a packet is received from the remote unit containing the Parallel Poll Response. The GPIB DIO lines are then driven with the response byte when it is received.

X.EOI and X.ATN are received on the remote side as R.EOI and R.ATN and propagated to the GPIB. Two microseconds later, the Parallel Poll Response on the remote side GPIB is sampled and returned as the Parallel Poll Response to the local unit. When the Parallel Poll Response is received by the local unit, the Parallel Poll Response byte is driven onto the GPIB DIO lines if the GPIB-110 is not in latched Parallel Poll mode.

When the Parallel Poll Response is received from the remote unit, and the local EOI signal goes false, the Parallel Poll-In-Progress state becomes false. This event causes the Parallel Poll register to latch the Parallel Poll Response when operating in latched Parallel Poll mode. The extender then stops driving NRFD true.

Data Direction Control

The unit drives the GPIB data lines DIO1-8 from R.DIO1-8 if there is a local Parallel Poll in progress or if the RS state is true and a remote Parallel Poll is not in progress. Otherwise, these lines are not driven.

When a packet containing DAV true or RPP true is received and unlatched parallel poll response mode is selected, the GPIB data lines are driven with the data from the data packet received from the remote unit. If DAV is not true during a Parallel Poll, the data lines are driven from the Parallel Poll Response register.

The local unit sends the data lines to the remote unit via X.DIO1-8 if there is a remote Parallel Poll in progress or if the LS state is true and a local Parallel Poll is not in progress. Otherwise, the data bytes are not sent.

EOI

The local unit transmits EOI to the remote unit as X.EOI if the LS state is true. X.EOI is asserted from the start of a local Parallel Poll until the poll handshake signal is received from the remote unit and the local poll completes.

X.EOI is received as R.EOI at the remote unit. X.EOI propagates to the remote GPIB if the local unit is conducting a Parallel Poll or if the RS state is true and the local unit is not conducting a Parallel Poll.

SRQ

The local GPIB unit transmits X.SRQ to the remote unit if the location of the Active Controller has not been detected. The remote unit drives the local bus according to the value of R.SRQ received.

When the location of the Active Controller has been detected, SRQ is sent to the remote unit only if the Active Controller is on the remote unit side.

Serial Communication Circuitry

The GPIB-110 units connected via a serial link maintain their communication through the use of digital packets. The serial communication circuitry is responsible for converting packets from parallel-to-serial form for transmission and back to parallel form after reception. The circuitry also maintains continuous communication between the extenders and is responsible for packet error-detection and recovery.

Link Establishment Protocol

The two GPIB-110s use a protocol in which each extender transmits a packet as soon as a packet is received. In this way, communication between the extenders is continuous. The LINK LED on the GPIB-110 front panel lights up when the unit is receiving error-free packets from the remote unit.

When you power on, the master GPIB-110 transmits a packet to the remote unit and waits approximately 30 µs for a packet to be received. If a packet is not received, the GPIB-110 times out and retransmits the packet. This process continues until a packet is received.

When you power on, the non-master GPIB-110 waits to receive a packet from the master GPIB-110 unit.

The extender link is established when a GPIB-110 receives two successive packets without errors. When the packets are received, the LINK LED on the front panel lights up indicating that the remote unit is turned on and operating properly. The extension is then operational.

When the remote unit no longer receives packets, the extender times out, turns off the LINK LED, and stops driving the local GPIB.

Serial Communication Protocol

The extender Serial Communication Protocol consists of each extender transmitting a packet whenever one is received while the link is established. In this way, each GPIB-110 unit can monitor that the remote unit is still on.

Transmission and reception of packets consists of four states:

- Receive Wait state
- Receive Packet state
- Transmit Synchronization state
- Transmit Packet state

If a communication error occurs, the GPIB-110 attempts to recover from the error as explained in the section, *Error Detection and Recovery*, later in this chapter.

Packet Format

Information is sent between GPIB-110 units via digital packets. The packet is made up of one or more start bits, followed by encoded GPIB information, and terminated by a cyclical redundancy check code. Each packet also contains a sequence number.

Receive Wait State

The Receive Wait state is entered after a packet has been transmitted to the remote unit. The GPIB-110 has a timeout circuit that corresponds to twice the propagation delay of 2 km of cable plus a GPIB-110 transmit wait time and the time it takes to transmit one packet. This equals approximately 26 µs plus the time it takes to transmit one packet, which varies depending on the transmit clock used. If a packet is not received within this time, the GPIB-110 goes into an error state.

Once a packet is received, the Receive Wait state is exited and the Receive Packet state is entered.

Receive Packet State

In the Receive Packet state, a packet is received and converted into parallel information as it is received. A redundancy check code is generated for the packet as it is received. This code is compared with the cyclical redundancy check code appended to the packet. If an error is detected, the packet is discarded. Otherwise, the packet information is latched and sent to the extension circuitry. The GPIB-110 then enters the Transmit Synchronization state.

Transmit Synchronization State

In the Transmit Synchronization state, the GPIB-110 waits up to approximately 3 µs for a change to occur on the local GPIB. A change consists of a change in the state of the IFC, REN, ATN, DAV, or RFD GPIB signals. When a change occurs or when the 3-µs time period has expired, the current state of the GPIB is sampled and the Transmit Packet state is entered.

Transmit Packet State

In the Transmit Packet state, the GPIB state information is serialized and start bits and sequence numbers are added. As the packet is transmitted, the cyclical redundancy check code is generated and appended to the packet. When this step is complete, the Receive Wait state is entered.

Error Detection and Recovery

In the GPIB-110, a communication error is recognized in one of two ways.

- If a packet is not received within a certain time limit from the previous transmission, the remote unit is turned off, and the GPIB-110 shuts down the GPIB-110 drivers and waits for resumption of communication as it does with the Link Establishment Protocol. Refer to the section, *Link Establishment Protocol*, earlier in this chapter.

- If a packet is received containing an error, the GPIB-110 attempts to recover from the error. A packet is received with an error if the cyclical redundancy check is wrong or the sequence number is wrong.

If either of these packet errors is detected, the packet is discarded. The GPIB-110 then retransmits the packet it had previously sent.

If two or more packets with errors are received in succession, the GPIB-110 unit assumes that the remote unit or the link is malfunctioning, and the GPIB-110 shuts down the GPIB drivers. The unit then waits for link establishment. Refer to the section, *Link Establishment Protocol*, earlier in this chapter.

System Timing and Transmission Clock

System timing for serial communication is based on the Transmit Clock, which is determined by the configuration switch setting. The clock starts when the start bit of a packet is received so that it can be synchronized to receive the incoming packet. The clock is then used to transmit the acknowledging packet. When the packet transmission has completed, the clock stops. The unit then waits for the next packet to be received.

Upon power on, or when the link is not established, the clock is started in the GPIB-110 master unit to allow packet transmission to proceed.

Appendix A
Hardware Specifications

This appendix lists the specifications of the GPIB-110.

System Configuration

Distance per extension	Up to 2 km
Loading per extension	Up to 14 additional devices
Multiple extensions	Permitted in any combination of star or linear pattern
GPIB driver output circuit and T1 timing of source device	No restrictions (automatic conversion to 0.5 µsec T1 delay on remote side is built-in)

Note: ***T1 is the data settling time (DIO valid to DAV) and varies according to the type of drivers and the system configuration used.***

Performance Characteristics

Speed	Up to 144 kbytes/sec (speed depends on type of serial link and distance). See Table A-1. No limitation to device speeds when there are no listeners on remote side of extension

Table A-1. Performance Versus Distance

Performance Measurement	Cable Type	Cable Length					
		short	**250 m**	**500 m**	**1000 m**	**1500 m**	**2000 m**
Max Data Transfer Rate (kbytes/sec)	Fiber Optic Coaxial	144.0 144.0	108.0 108.0	85.0 33.0	56.0 17.9	44.0 1.6	36.0 0.4
Max SRQ Prop. Delay (µsec)	Fiber Optic Coaxial	11.0 11.6	14.0 14.8	18.0 35.4	27.0 67.0	35.0 378.0	44.0 1450.0
Max Parallel Poll Response Delay (µsec)	Fiber Optic Coaxial	17.0 23.9	21.0 30.8	26.0 53.2	38.0 98.0	48.0 606.0	58.0 2340.0

Functionality	Transparent GPIB operation except for *latched* parallel polls
Interlocked IEEE 488 handshake	Maintained across the extension
IEEE 488 capability identification AH1 codes	SH1 Complete source handshake AH1 Complete acceptor handshake T5,TE5 Complete Talker L3, LE3 Complete Listener SR1 Complete service request RL1 Complete remote local PP1, 2 Complete parallel poll DC1 Complete device clear DT1 Complete device trigger C1-5 Complete controller E2 Tri-state GPIB drivers

Operating Characteristics

Architecture	Synchronous (clocked) design point-to-point (not multidrop) transmission
Operating modes	Immediate extension or IFC wait extension
Parallel poll response modes	Latched parallel poll response or unlatched parallel poll response

Electrical Characteristics

GPIB interface circuit	Duplex transceivers with tri-state drivers for IFC, ATN, DAV and EOI (MC3448), and the DIO lines (DS75160AN). Duplex transceivers with open collector drivers for REN, SRQ, NRFD, and NDAC (MC3441).
Transmission interface circuit	Optically isolated coaxial drivers (75121) and receivers (75122) with BNC connectors. Optical transmitter (HFM2010-224) and receiver (HFM1011-221) with SMA-style optical cable connectors.

Table A-2. Electrical Specifications

Characteristic	Specification
Power Supply Unit	100 to 120 VAC, 50 to 50 Hz, or 220 to 240 VAC, 50 to 60 Hz
Maximum Current Requirement	100 to 120 VAC, 200mA 220 to 240 VAC, 100mA
Fuse Rating and Type	100 to 120 VAC, 300mA, 250V, SLOBLO, UL/CSA Approved 220 to 240 VAC, 200mA, 250V, SLOBLO, IEC Approved

Caution: ***Replacement fuses should be the correct type and rating. Refer to the section entitled, Electrical Characteristics, for fuse information.***

Environmental Characteristics

Operating temperature	0° to 45° C
Humidity	5% to 95% non-condensing conditions
FCC	Class A verified

Physical Characteristics

Case style	CS2
Size	3.5 in. by 8.5 in. by 13 in. (89 mm by 216 mm by 330 mm)
Case material	UL94V-0 flame-retardant polystyrene Dow 60875F or equivalent
Rack-mounting	Single or dual kits available
GPIB cable	National Instruments part number 763061-xx or equivalent
Transmission cable	Belden V.P.C. part number 95680 75 Ω coaxial cable 9248, RG-6/U type with male BNC connectors.
	Optical Cable Corporation fiber optic cable A02-030D-C4DB/900. 3 mm cable diameter. Flame-retardant PVC jacket. Graded, 100/140 micron core/clad with a minimum NA of 0.28. 850 nm operating wavelength. 4 dB/km attenuation. 100 MHz-km fiber bandwidth. Duplex style, terminated with aluminum SMA-style connectors.

Appendix B
Multiline Interface Messages

This appendix lists the multiline interface messages and describes the mnemonics and messages that correspond to the interface functions. These functions include initializing the bus, addressing and unaddressing devices, and setting device modes for local or remote programming. The multiline interface messages are IEEE 488-defined commands that are sent and received with ATN TRUE.

For more information on these messages, refer to the ANSI/IEEE Standard 488-1987, *IEEE Standard Digital Interface for Programmable Instrumentation.*

Multiline Interface Messages

Hex	Oct	Dec	ASCII	Msg	Hex	Oct	Dec	ASCII	Msg
00	000	0	NUL		20	040	32	SP	MLA0
01	001	1	SOH	GTL	21	041	33	!	MLA1
02	002	2	STX		22	042	34	"	MLA2
03	003	3	ETX		23	043	35	#	MLA3
04	004	4	EOT	SDC	24	044	36	$	MLA4
05	005	5	ENQ	PPC	25	045	37	%	MLA5
06	006	6	ACK		26	046	38	&	MLA6
07	007	7	BEL		27	047	39	'	MLA7
08	010	8	BS	GET	28	050	40	(	MLA8
09	011	9	HT	TCT	29	051	41	)	MLA9
0A	012	10	LF		2A	052	42	*	MLA10
0B	013	11	VT		2B	053	43	+	MLA11
0C	014	12	FF		2C	054	44	,	MLA12
0D	015	13	CR		2D	055	45	-	MLA13
0E	016	14	SO		2E	056	46	.	MLA14
0F	017	15	SI		2F	057	47	/	MLA15
10	020	16	DLE		30	060	48	0	MLA16
11	021	17	DC1	LLO	31	061	49	1	MLA17
12	022	18	DC2		32	062	50	2	MLA18
13	023	19	DC3		33	063	51	3	MLA19
14	024	20	DC4	DCL	34	064	52	4	MLA20
15	025	21	NAK	PPU	35	065	53	5	MLA21
16	026	22	SYN		36	066	54	6	MLA22
17	027	23	ETB		37	067	55	7	MLA23
18	030	24	CAN	SPE	38	070	56	8	MLA24
19	031	25	EM	SPD	39	071	57	9	MLA25
1A	032	26	SUB		3A	072	58	:	MLA26
1B	033	27	ESC		3B	073	59	;	MLA27
1C	034	28	FS		3C	074	60	<	MLA28
1D	035	29	GS		3D	075	61	=	MLA29
1E	036	30	RS		3E	076	62	>	MLA30
1F	037	31	US		3F	077	63	?	UNL

Message Definitions

DCL Device Clear
GET Group Execute Trigger
GTL Go To Local
LLO Local Lockout
MLA My Listen Address
MSA My Secondary Address
MTA My Talk Address
PPC Parallel Poll Configure
PPD Parallel Poll Disable

Multiline Interface Messages

Hex	Oct	Dec	ASCII	Msg	Hex	Oct	Dec	ASCII	Msg
40	100	64	@	MTA0	60	140	96	`	MSA0,PPE
41	101	65	A	MTA1	61	141	97	a	MSA1,PPE
42	102	66	B	MTA2	62	142	98	b	MSA2,PPE
43	103	67	C	MTA3	63	143	99	c	MSA3,PPE
44	104	68	D	MTA4	64	144	100	d	MSA4,PPE
45	105	69	E	MTA5	65	145	101	e	MSA5,PPE
46	106	70	F	MTA6	66	146	102	f	MSA6,PPE
47	107	71	G	MTA7	67	147	103	g	MSA7,PPE
48	110	72	H	MTA8	68	150	104	h	MSA8,PPE
49	111	73	I	MTA9	69	151	105	i	MSA9,PPE
4A	112	74	J	MTA10	6A	152	106	j	MSA10,PPE
4B	113	75	K	MTA11	6B	153	107	k	MSA11,PPE
4C	114	76	L	MTA12	6C	154	108	l	MSA12,PPE
4D	115	77	M	MTA13	6D	155	109	m	MSA13,PPE
4E	116	78	N	MTA14	6E	156	110	n	MSA14,PPE
4F	117	79	O	MTA15	6F	157	111	o	MSA15,PPE
50	120	80	P	MTA16	70	160	112	p	MSA16,PPD
51	121	81	Q	MTA17	71	161	113	q	MSA17,PPD
52	122	82	R	MTA18	72	162	114	r	MSA18,PPD
53	123	83	S	MTA19	73	163	115	s	MSA19,PPD
54	124	84	T	MTA20	74	164	116	t	MSA20,PPD
55	125	85	U	MTA21	75	165	117	u	MSA21,PPD
56	126	86	V	MTA22	76	166	118	v	MSA22,PPD
57	127	87	W	MTA23	77	167	119	w	MSA23,PPD
58	130	88	X	MTA24	78	170	120	x	MSA24,PPD
59	131	89	Y	MTA25	79	171	121	y	MSA25,PPD
5A	132	90	Z	MTA26	7A	172	122	z	MSA26,PPD
5B	133	91	[	MTA27	7B	173	123	{	MSA27,PPD
5C	134	92	\	MTA28	7C	174	124	|	MSA28,PPD
5D	135	93	]	MTA29	7D	175	125	}	MSA29,PPD
5E	136	94	^	MTA30	7E	176	126	~	MSA30,PPD
5F	137	95	_	UNT	7F	177	127	DEL	

PPE	Parallel Poll Enable	SPE	Serial Poll Enable
PPU	Parallel Poll Unconfigure	TCT	Take Control
SDC	Selected Device Clear	UNL	Unlisten
SPD	Serial Poll Disable	UNT	Untalk

Interface Message Reference List

Local Messages Received (by interface functions)

Mnemonic	Message	Interface Function(s)
gts	go to standby	C
ist	individual status qualifier	PP
lon	listen only	L, LE
[lpe]	local poll enable	PP
ltn	listen	L, LE
lun	local unlisten	L, LE
nba	new byte available	SH
pon	power on	SH, AH, T, TE, L, LE, SR, RL, PP, C
rdy	ready	AH
rpp	request parallel poll	C
rsc	request system control	C
rsv	request service	SR
rtl	return to local	RL
sic	send interface clear	C
sre	send remote enable	C
tca	take control asynchronously	C
tcs	take control synchronously	AH, C
ton	talk only	T, TE

Remote Messages Received

Mnemonic	Message	Interface Function(s)
ATN	attention	SH, AH, T, TE, L, LE, PP, C
DAB	data byte	(via L, LE)
DAC	data accepted	SH
DAV	data valid	AH
DCL	device clear	DC
END	end	(via L, LE)
GET	group execute trigger	DT
GTL	go to local	RL
IDY	identify	L, LE, PP
IFC	interface clear	T, TE, L, LE, C
LLO	local lockout	RL
MLA	my listen address	L, LE, RL
[MLA]	my listen address	T
MSA or [MSA]	my secondary address	TE, LE
MTA	my talk address	T, TE
[MTA]	my talk address	L
OSA	other secondary address	TE
OTA	other talk address	T, TE
PCG	primary command group	TE, LE, PP
PPC	parallel poll configure	PP
[PPD]	parallel poll disable	PP
[PPE]	parallel poll enable	PP

Interface Message Reference List (Continued)

Remote Messages Received (Continued)

Mnemonic	Message	Interface Function(s)
PPRn	parallel poll response n	(via C)
PPU	parallel poll unconfigure	PP

Remote Messages Sent

Mnemonic	Message	Interface Function(s)
REN	remote enable	RL
RFD	ready for data	SH
RQS	request service	(via L, LE)
[SDC]	selected device clear	DC
SPD	serial poll disable	T, TE
SPE	serial poll enable	T, TE
SRQ	service request	(via C)
STB	status byte (via L, LE)	
TCT or [TCT]	take control	C
UNL	unlisten	L, LE
ATN	attention	C
DAB	data byte	
DAC	data accepted	AH
DAV	data valid	SH
DCL	device clear	(via C)
END	end	(via T)
GET	group execute trigger	(via C)
GTL	go to local	(via C)
IDY	identify	C
IFC	interface clear	C
LLO	local lockout	(via C)
MLA or [MLA]	my listen address	(via C)
MSA or [MSA]	my secondary address	(via C)
MTA or [MTA]	my talk address	(via C)
OSA	other secondary address	(via C)
OTA	other talk address	(via C)
PCG	primary command group	(via C)
PPC	parallel poll configure	(via C)
[PPD]	parallel poll disable	(via C)
[PPE]	parallel poll enable	(via C)
PPRn	parallel poll response n	PP
PPU	parallel poll unconfigure	(via C)
REN	remote enable	C
RFD	ready for data	AH
RQS	request service	T, TE
[SDC]	selected device clear	(via C)
SPD	serial poll disable	(via C)
SPE	serial poll enable	(via C)
SRQ	service request	SR

Interface Message Reference List (Continued)

Remote Messages Sent (Continued)

Mnemonic	Message	Interface Function(s)
STB	status byte	(via T, TE)
TCT	take control	(via C)
UNL	unlisten	(via C)
UNT	untalk	(via C)

Appendix C
Operation of the GPIB

This appendix describes some basic concepts you should understand to operate the GPIB. It also contains a description of the physical and electrical characteristics as well as configuration requirements of the GPIB.

History of the GPIB

The GPIB is a link, or bus, or interface system through which interconnected electronic devices communicate. Hewlett-Packard invented the GPIB, which they call the HP-IB, to connect and control programmable instruments manufactured by them. Because of its high data transfer rates of over 1 Mbytes/s, the GPIB gained popularity in other applications such as intercomputer communication and peripheral control. It was later accepted as the industry standard ANSI/IEEE Standard 488-1987. The versatility of the system prompted the name General Purpose Interface Bus.

Types of Messages

Devices on the GPIB communicate by passing messages through the interface system. The two types of messages are device-dependent messages and interface messages.

- Device-dependent messages, often called *data* or *data messages*, contain device-specific information such as programming instructions, measurement results, machine status, and data files.
- Interface messages manage the bus itself. They are usually called *commands* or *command messages*. Interface messages perform such tasks as initializing the bus, addressing and unaddressing devices, and setting devices for remote or local programming.

The term *command* as used here should not be confused with some device instructions which are also called commands. Such device-specific instructions are actually data messages.

Talkers, Listeners, and Controllers

A *Talker* sends data messages to one or more *Listeners*. The *Controller* manages the flow of information on the GPIB by sending commands to all devices.

Devices can be Talkers, Listeners, and/or Controllers. A digital multimeter, for example, is a Talker and can also be a Listener. A printer or plotter is usually only a Listener. A computer on the GPIB often combines all three roles to manage the bus and communicate with other devices.

The GPIB is a bus like a typical computer bus except that the computer has its circuit cards interconnected via a backplane bus whereas the GPIB has stand-alone devices interconnected via a cable bus.

The role of the GPIB Controller can also be compared to the role of the CPU of a computer, but a better analogy is to the switching center of a city telephone system.

The switching center (Controller) monitors the communications network (GPIB). When the center (Controller) notices that a party (device) wants to make a call (send a data message), it connects the caller (Talker) to the receiver (Listener).

The Controller usually addresses a Talker and a Listener before the Talker can send its message to the Listener. After the message is transmitted, the Controller usually unaddresses both devices.

Some bus configurations do not require a Controller. For example, one device may only be a Talker (called a Talk-only device) and there may be one or more Listen-only devices.

A Controller is necessary when the active or addressed Talker or Listener must be changed. The Controller function is usually handled by a computer.

With the GPIB interface board, your personal computer plays all three roles.

- Controller–manages the GPIB
- Talker–sends data
- Listener–receives data

Controller-In-Charge and System Controller

Although there can be multiple Controllers on the GPIB, only one Controller at a time is Active Controller or Controller-in-Charge (CIC). Active control can be passed from the current Active Controller to an idle Controller. Only one device on the bus, the System Controller, can make itself the CIC.

GPIB Signals and Lines

The interface bus consists of 16 signal lines and 8 ground return or shield drain lines. The 16 signal lines are divided into three groups:

- Eight data lines
- Three handshake lines
- Five interface management lines

Figure C-1 shows the arrangement of these signals on the GPIB cable connector.

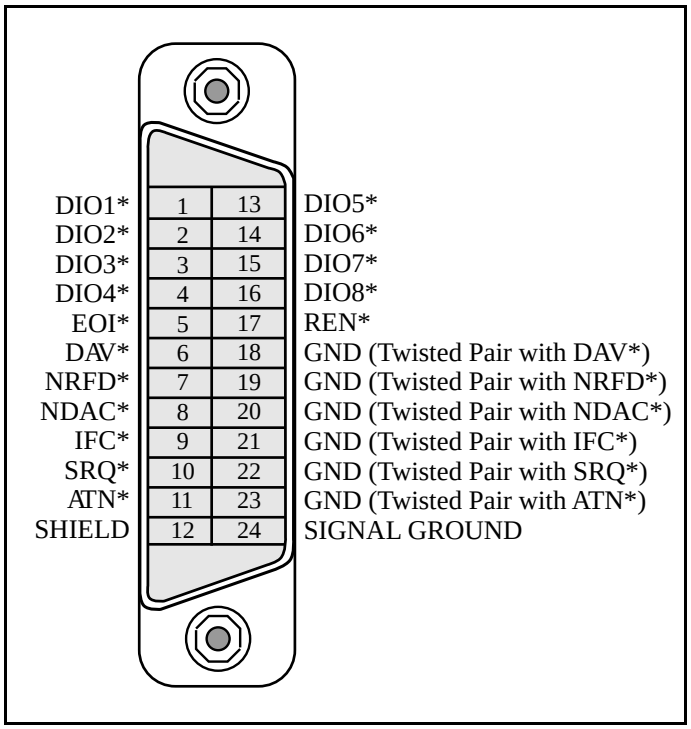

DIO1* 1 13 DIO5*
DIO2* 2 14 DIO6*
DIO3* 3 15 DIO7*
DIO4* 4 16 DIO8*
EOI* 5 17 REN*
DAV* 6 18 GND (Twisted Pair with DAV*)
NRFD* 7 19 GND (Twisted Pair with NRFD*)
NDAC* 8 20 GND (Twisted Pair with NDAC*)
IFC* 9 21 GND (Twisted Pair with IFC*)
SRQ* 10 22 GND (Twisted Pair with SRQ*)
ATN* 11 23 GND (Twisted Pair with ATN*)
SHIELD 12 24 SIGNAL GROUND

Figure C-1. GPIB Cable Connector

Data Lines

The eight data lines, DIO1 through DIO8, carry both data and command messages. All commands and most data use the 7-bit ASCII or ISO code set, in which case the 8th bit, DIO8, is unused or used for parity.

The GPIB command messages are listed in Appendix B, *Multiline Interface Messages*.

Handshake Lines

Three lines asynchronously control the transfer of message bytes among devices. The process is called a three-wire interlocked handshake and it guarantees that message bytes on the data lines are sent and received without transmission error.

NRFD (not ready for data)

NRFD indicates when a device is ready or not ready to receive a message byte. The line is driven by all devices when receiving commands and by Listeners when receiving data messages.

NDAC (not data accepted)

NDAC indicates when a device has or has not accepted a message byte. The line is driven by all devices when receiving commands and by Listeners when receiving data messages.

DAV (data valid)

DAV tells when the signals on the data lines are stable (valid) and can be accepted safely by devices. The Controller drives DAV when sending commands and the Talker drives it when sending data messages.

The way in which NRFD and NDAC are used by the receiving device is called the Acceptor Handshake. Likewise, the sending device uses DAV in the Source Handshake.

Interface Management Lines

Five lines are used to manage the flow of information across the interface.

ATN (attention)

The Controller drives ATN true when it uses the data lines to send commands and false when it allows a Talker to send data messages.

IFC (interface clear)

The System Controller drives the IFC line to initialize the bus to become CIC.

REN (remote enable)

The System Controller drives the REN line, which is used to place devices in remote or local program mode.

SRQ (service request)

Any device can drive the SRQ line to asynchronously request service from the CIC with the SRQ line.

EOI (end or identify)

The EOI line has two purposes. The Talker uses it to mark the end of a message string. The CIC uses it to tell devices to identify their responses in a parallel poll.

Physical and Electrical Characteristics

Devices are usually connected with a cable assembly consisting of a shielded 24-conductor cable with both a plug and receptacle at each end. This design allows devices to be connected in either a linear or a star configuration, or a combination of the two. See Figures C-2 and C-3.

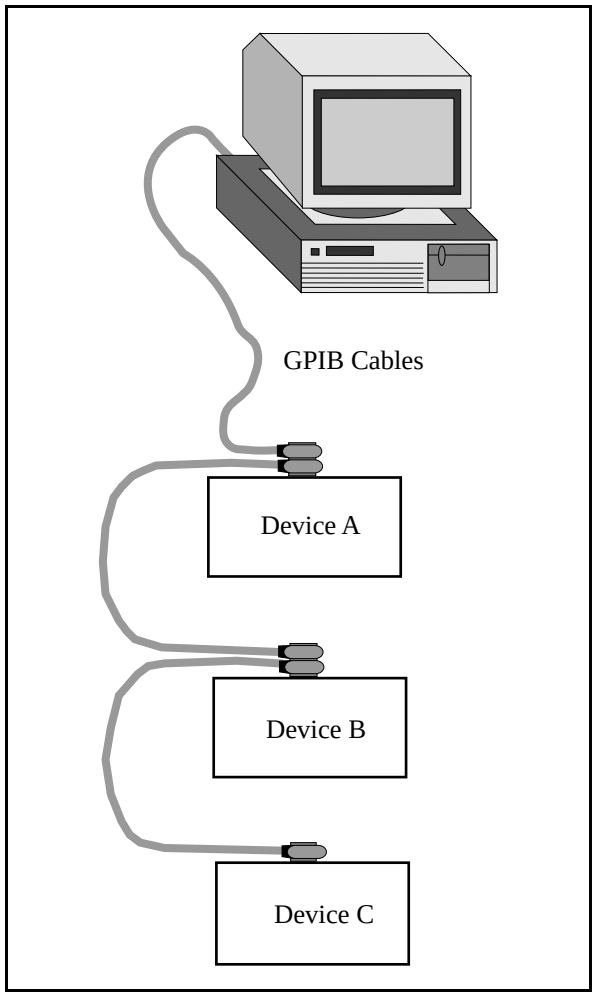


Figure C-2. Linear Configuration of the GPIB Devices

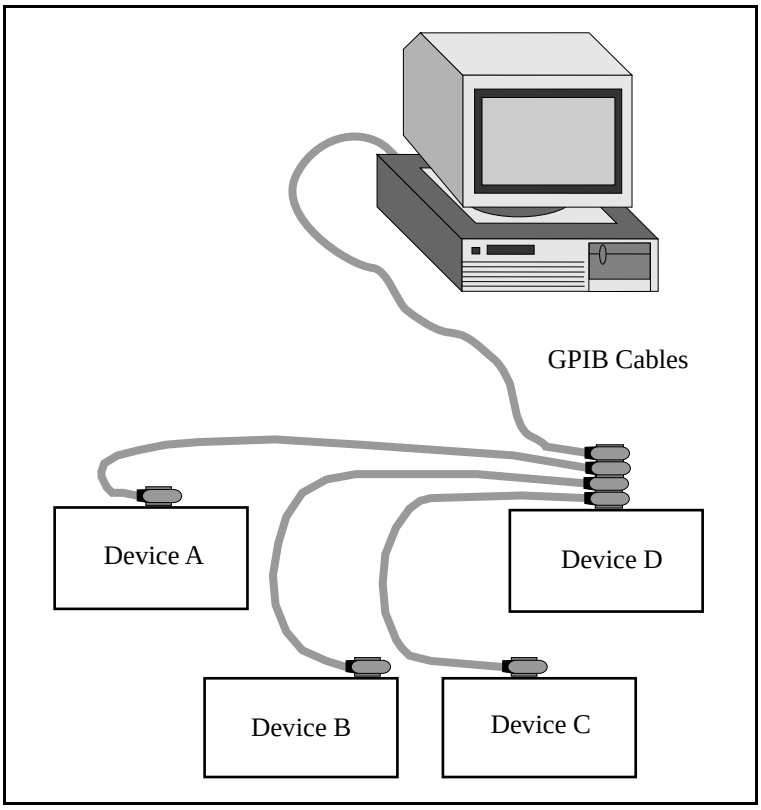


Figure C-3. Star Configuration of GPIB Devices

The standard connector is the Amphenol or Cinch Series 57 *Microribbon* or *Amp Champ* type. An adapter cable using non-standard cable and/or connector is used for special interconnect applications.

The GPIB uses negative logic with standard transistor-transistor logic (TTL) levels.

For example, when DAV is true, it is a TTL low level (≤ 0.8 V), and when DAV is false, it is a TTL high level (≥ 2.0 V).

Configuration Restrictions: The Role of Extenders and Expanders

To achieve the high data transfer rate that the GPIB is designed for, the physical distance between devices and the number of devices on the bus is limited.

The following restrictions are typical:

- A maximum separation of 4 m between any two devices and an average separation of 2 m over the entire bus.
- A maximum total cable length of 20 m.
- No more than 15 devices connected to each bus, with at least two-thirds of the devices turned on.

You can usually connect a cluster of lab instruments without exceeding these restrictions. However, many applications require longer cable spans or additional loading.

From the time the GPIB was invented, the need existed for bus extenders and expanders (repeaters). Extenders connect two separate buses via a transmission medium, and the distance between the buses can be quite long. Expanders or repeaters generally buffer one bus from an adjacent bus that doubles the total cable and loading limits.

The GPIB-110 is a serial extender that uses either low-cost coaxial cable or high-performance electrically isolated fiber-optic cable as its transmission medium. The GPIB-110 samples GPIB signals on each bus to which it is connected, serializes the information encoded in small packets, and transmits the packets to the remote side. Separate packets are sent for each message or byte handshaking, maintaining GPIB synchronization between both connected buses.

The GPIB-110 uses a handshake protocol that allows it to maintain optimum communication between both extenders in the link. In addition, a low-bit cyclical redundancy code is used to detect serial transmission errors. The GPIB-110 recovers automatically from detected errors.

National Instruments also manufactures a parallel extender, the GPIB-130. This extender relays the instantaneous status of all GPIB signals over an RS-422 compatible cable and allows up to a 300 m extension.

The National Instruments GPIB-120A is a high-speed GPIB expander that allows up to 14 additional devices to be connected to the bus and 20 m of cable length to be added to the system. In addition, optical isolation is provided between the two connected GPIBs to prevent ground loop and noise problems. Only one GPIB-120A is required per expansion.

Appendix D
Customer Communication

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve technical problems you might have as well as a form you can use to comment on the product documentation. Filling out a copy of the *Technical Support Form* before contacting National Instruments helps us help you better and faster.

National Instruments provides comprehensive technical assistance around the world. In the U.S. and Canada, applications engineers are available Monday through Friday from 8:00 a.m. to 6:00 p.m. (central time). In other countries, contact the nearest branch office. You may fax questions to us at any time.

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Denmark	45 76 26 00	45 76 71 11
Finland	(90) 527 2321	(90) 502 2930
France	(1) 48 14 24 00	(1) 48 14 24 14
Germany	089/741 31 30	089/714 60 35
Italy	02/48301892	02/48301915
Japan	(03) 3788-1921	(03) 3788-1923
Netherlands	03480-33466	03480-30673
Norway	32-848400	32-848600
Spain	(91) 640 0085	(91) 640 0533
Sweden	08-730 49 70	08-730 43 70
Switzerland	056/20 51 51	056/20 51 55
U.K.	0635 523545	0635 523154

Technical Support Form

Photocopy this form and update it each time you make changes to your software or hardware, and use the completed copy of this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

If you are using any National Instruments hardware or software products related to this problem, include the configuration forms from their user manuals. Include additional pages if necessary.

Name _____

Company _____

Address _____

_____

Fax (___) _____ Phone (___) _____

Computer brand _____ Model _____ Processor _____

Operating system _____

Speed _____MHz RAM _____M Display adapter _____

Mouse _____yes _____no Other adapters installed _____

Hard disk capacity _____M Brand _____

Instruments used _____

National Instruments hardware product model _____ Revision _____

Configuration _____

National Instruments software product _____ Version _____

Configuration _____

The problem is _____

_____

_____

_____

_____

List any error messages _____

_____

_____

_____

_____

The following steps will reproduce the problem _____

_____

_____

GPIB-110 Hardware and Software Configuration Form

Record the settings and revisions of your hardware and software on the line to the right of each item. Update this form each time you revise your software or hardware configuration, and use this form as a reference for your current configuration.

National Instruments Products

- GPIB-110 Revision _____
- Remote GPIB-110 Revision _____
- National Instruments GPIB Interface _____
- National Instruments Software _____
- Fiber Optic or Coax Cable or Both _____
  - Length of cable _____

Other Products

- Computer Make and Model _____
- Operating System Version _____
- Number of GPIB Devices on Bus _____
- Other Boards in System _____
- GPIB Devices in System _____
- Other Cables in Systems _____
  - Type and Manufacturer _____
  - Length of cable _____

Documentation Comment Form

National Instruments encourages you to comment on the documentation supplied with our products. This information helps us provide quality products to meet your needs.

Title: **GPIB-110 User Manual**

Edition Date: **August 1994**

Part Number: **320052-01**

Please comment on the completeness, clarity, and organization of the manual.

If you find errors in the manual, please record the page numbers and describe the errors.

Thank you for your help.

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Glossary

Prefix	Meaning	Value
n-	nano-	10^{-9}
µ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}

°	degrees
≥	is greater than or equal to
≤	is less than or equal to
Ω	ohms
%	percent
A	amperes
AC	Active Controller
AC	alternating current
ASCII	American Standard Code for Information Exchange
BNC	refers to coaxial cable connector
C	Celsius
CIC	Controller-In-Charge
CPU	central processing unit
dB	decibels
DC	direct current
EOI	End-or-Identify
ERR	Error bit
FCC	Federal Communications Commission
FO	fiber optic
GPIB	General Purpose Interface Bus
HP	Hewlett-Packard
Hz	hertz
IDY	Identify message
IFC	Interface Clear
in.	inches
ISO	International Standards Organization
kbytes	1,000 bytes
LAC	Local Active Controller
LED	light-emitting diode
LOC	Local LED
LS	Local Source state

LSC	Local System Controller
m	meters
MB	megabytes of memory
Mbytes	1,000,000 bytes
NA	numerical aperture
PPR	Parallel Poll Response
PVC	Polyvinylchloride
RAC	Remote Active Controller
REM	Remote LED
RS	Remote Source state
RSC	Remote System Controller
s	seconds
TTL	transistor-transistor logic
V	volts
VAC	volts alternating current
W	watts

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